

Every Day Counts (EDC) Ultra-High Performance Concrete (UHPC) Workshop Report

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Purpose: Provide a one-day Every Day Counts (EDC) Ultra-High Performance Concrete (UHPC) workshop for the NHDOT. This workshop is the thirteenth in a series conducted by Leidos Incorporated under contract (DTFH6116F00013) with FHWA.

Activities/Description: On Tuesday, May 2, 2017, Mark Leonard (FHWA) and Andy Foden (WSP USA) delivered the one day workshop to 53 participants from public and private sectors at the NHDOT Building in Concord, NH.

During the workshop, instructors passed around several samples of UHPC components (fibers, dry mix, etc.), casted, and tested materials, including:

- A small beam tested until failure, with cracks on it.
- Samples of UHPC made with organic fiber.
- Two dry mixes (white-colored and regular): ground cement, sand, quartz mix.
- Steel fibers, organic fibers.
- A sample material from a tensile test, showing the interior of UHPC.
- Bond-tested cylinder with conventional concrete plus a UHPC layer.

Agenda,
Attendees,
Evaluations:

A copy of the agenda, evaluations, and the sign-in sheet are attached below.



UHPC Workshop
Agenda NH.pdf



NH Evaluations.pdf

Q&A and
Discussion:

The following are the questions and comments that came up during the workshop.

- What kind of surface does the UHPC, shown flowing in the video for a bridge deck panel connection, have when it is set?
 - When used to connect deck panels, UHPC is poured with overfill around a quarter inch higher than the top of the precast deck panels. After the UHPC sets, it is ground flush with the surface. In this case you do not get the smooth surface as with the samples passed around in the workshop.
- How does UHPC turn into the surface finish of the samples that we passed around here today?
 - UHPC is self-consolidating and will take the shape of the form it is placed in, and provide a smooth surface finish. That is one of the reasons it has a lot of architectural applications.
- Have you ever experienced a halo effect where chlorides are penetrating into the precast panels but not into the UHPC? That could lead to a concentration of chlorides around the connection. What happens then and what is the solution?
 - We have not seen examples of that after 10 years of field applications.
 - Precast panels have lower permeability, and are still a better option, than cast-in place concrete.
- Can UHPC connections on precast side-by-side box girders be used without overlay?
 - Yes, they can. The overlays are not necessary, but we have not seen many box girder applications without overlays.
- How much distance is needed from the end of the rebar to the joint?
 - 1-inch distance is the rule of thumb, but it can be slightly more or less depending on your fit-up construction tolerances and fiber length.
- How frequent should the pour heads be placed?
 - It is important to make sure the UHPC does not flow any farther than 10 feet. Longer flows may cause fiber alignment and lead to anisotropic properties thereby reducing the shear strength in the haunch.
- Are there any rules to ensure that UHPC has the right viscosity to be placed into joints?
 - Yes, flow tests ensure proper viscosity of the mix.
- How can we de-bond the upper portion of anchorages, as mentioned in the FHWA guidelines for ducted substructure connections?
 - You could use grease, duct tape, or a grout sleeve. Duct tape is the most common method.
- What are the wire ties shown on the slide in the joint gaps for?

- The wire ties are to hold the bottom form. Some owners or contractors prefer to hang the bottom form with wire ties instead of using concrete screws.
- Does the UHPC shrink?
 - Yes, it does. The shrinkage properties are comparable to cementitious grouts. Joint gaps are usually very small widths, around 8 inches, thus the shrinkage of the material is minimal.
- How does the Modulus of elasticity compare between the panels and UHPC connection? Is there an issue with fracture at the connection?
 - Modulus of elasticity of UHPC is around 6,000-8,000 ksi, so it is stiffer than the precast concrete. There have not been problems with the connection of precast deck panels in the laboratory tests.
- Is there a specific method to store the test cylinders on site?
 - No, there is no difference between storing UHPC cylinders and storing traditional concrete. Any on-site curing should be conducted on cylinders as usual. If a heat-cure is applied to the connection, cylinders should be cured similarly to get accurate early compression results.
- How much heat does the UHPC self-generate?
 - It does generate a significant amount of heat, reducing the workability window compared to regular concrete. Thus, adding ice instead of water allows longer workability.
- Is the variety of workability time just related to the ambient temperature?
 - The mix design and temperature of the mix are the primary influences on working time. During warmer months, using up to 100 percent ice instead of water is a common practice. The flow test will indicate the amount of ice to be used.
- What is the standard working time of UHPC?
 - It is usually workable for 2-3 hours without any retarders. This period can be extended with retarders. However, agencies have reported significantly less than 2-3 hours when using early strength mix designs in warm weather.
- Does heat curing in cold weather impact the ultimate strength?
 - No, it has little to no impact on the ultimate strength. The concern is that in cold weather it takes longer for UHPC to set and get stiff. If it is too cold, and the connection is subject traffic vibrations before the UHPC sets, then heat cure is necessary to accelerate setup and prevent fiber settlement.
- In the New York example project on I-81 over Calthrop Avenue, there was a half-inch thick over-pour. What was the reasoning for that?
 - That is to allow for grinding of the entire deck to obtain a precise profile. The over-pour also helps to accelerate construction because the panels do not need to be set to the exact final height.
- Is there any disadvantage of having steel fibers exposed on the bridge deck?
 - As long as pedestrians are not walking with bare feet there is no issue. Those fibers will not affect grinding either. Plus, the exposed steel fibers will corrode quickly and will be naturally swept away from the surface. Overlays can be an option when pedestrians are a concern.
- Are the curing specifications based on the product?

- Yes, it depends on the product as well as the ambient temperature and conditions. It also depends on the need for accelerated strength gain.
- What are the calculations to determine shim heights?
 - This is the same procedure you would use to calculate haunch heights. You survey the top point of the steel and you know the proposed elevation and deck panel height. You need to calculate the top of deck minus deck thickness and girder deflection from dead load.
- What is the unit weight of UHPC?
 - Typically, 155 lbs./ft³ for design purposes.
- How do we ensure that steel fibers are distributed randomly?
 - It is important to make sure the UHPC does not flow any farther than 10 feet, that the quality control tests are done properly, and that the mix designs are correct. If everything was done correctly, it should not be an issue.
- What should be done for the UHPC to UHPC cold joint connections? Will it have a weaker bond at bulk heads?
 - Normally those cold joints are located where there is no need for structural continuity. Bulkhead connections are generally not a concern, for a few reasons. First, the UHPC is just joining the panels together, so the UHPC to UHPC connection is not a concern for structural properties. Second, there is no rebar going through bulk heads, so nothing can become corroded even if water gets in.
- How close are the FHWA Tech Note guidelines to being incorporated into AASHTO standards?
 - There have been discussions with the AASHTO T-10 Concrete Design Committee but there is no timeline yet. FHWA is working on developing some specifications in AASHTO format and sharing them with the committee.

New Hampshire DOT Implementation of UHPC: Interactive Discussion

Robert Landry, administrator of NHDOT Bridge Design Division kicked off the discussion regarding UHPC use in their State. Mr. Landry stated the NHDOT's interest in moving forward with UHPC and invited all the participants to bring him their recommendations on where to use UHPC. NHDOT is also very interested in UHPC overlay applications to extend the lifespan of their bridges.

He also mentioned budget limitations, as well as NHDOT's push towards accelerated bridge construction (ABC). New Hampshire has several upcoming bridge projects, including a major bridge on I-95 to be replaced in 2027. Another ABC design-build project for New Hampshire is coming up on US Route 4 and is planned to be completed with a 14-day closure. NHDOT is currently working to select the contractor for the project.

NHDOT's main concern on implementing UHPC is the sole-source supplier. Previously, public interest finding documentation allowed them to use UHPC for a bridge project in East Kingston.

New Hampshire's District 13 indicated that they have an upcoming project, designed without using UHPC; however, they may review the designs after the workshop to evaluate the value of using UHPC. District 13 also may have several bridge projects coming up, that would be good candidates for UHPC implementation.

Q&A During the Discussion

- Has a class been developed for contractors so they have a better understanding of how to work with UHPC which should then be reflected in their bids?
 - For this workshop, we encourage the participation of contractors. However, often it is not very convenient and common for contractors to attend the workshop. The recordings of the webinars will be available to the contracting community. The webinars will also feature contractors as guest speakers.
 - Having a mandatory pre-bid meeting to present parts of the UHPC workshop can also educate the contractors.
- How can we procure the mixers for UHPC?
 - They are available for rent, but often they are provided by the material supplier. For an overlay project in Iowa, the local public works department rented the machines.
- Does NHDOT use bare concrete decks?
 - Yes, we are trying to push for bare concrete decks. Previously, New Hampshire had many membrane and asphalt bridge decks but now we are willing to explore other options to make an ABC approach possible.
- How well does UHPC bond with epoxy coated bars?
 - The FHWA guidelines for development and splice lengths are the same for both epoxy coated and black rebars.
- Are there any examples of using GFRP bars with UHPC? Are there any equations for the development length and other design calculations for such applications?
 - There are not many examples of using GFRP with UHPC. It is not common in the United States. In Canada, the balance cantilever bridge over Nipigon River was built with GFRP; however, we do not know what equations were used for development length. The FHWA Tech Note advises on how to adjust the equations for steel bars that have strength values higher than 75 ksi.
- Should the State specifications indicate and/or require tests for the UHPC connection formwork?
 - Even though such a test is not in the FHWA guidelines it is probably a good idea. New York State has a test to determine whether the formwork is watertight in their specifications based on their early experiences. Having a mock-up of the formwork will also help identify any potential issues before implementation in the field.

References:

<https://www.fhwa.dot.gov/research/resources/uhpc/>

<https://www.fhwa.dot.gov/research/resources/uhpc/publications.cfm>

https://www.fhwa.dot.gov/innovation/everydaycounts/edc_4/uhpc.cfm